Radioelectrocardiography in Diagnosis of Rhythm Disturbances in Patients with Implanted Cardiac Pacemakers

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The electrical pacemakers widely used in treatment of patients with impaired atrioventricular conduction can under certain circumstances produce new disturbances of rhythm. Such disturbances may result from alteration of haemodynamic conditions (Sowton, 1965), improved blood supply, changes in myocardial threshold caused by prolonged artificial stimulation, or from a failure of pacemaker assembly (Furman et al., 1966). They may also be due to the technical properties of a particular type of pacemaker.

Most of these arrhythmias become apparent soon after implantation of the pacemaker, but some do not show until the patient is fully active. The latter are difficult to detect with the electrocardiogram at rest. Radioelectrocardiography makes it possible to reveal them during physical activity.

SUBJECTS AND METHODS

In 53 patients admitted to the 4th Clinic of Internal Diseases of the Warsaw Medical Academy in the period 1964–67, a total of 65 pacemakers was implanted or re-implanted in co-operation with the Clinic of Thoracic Surgery of the Warsaw Institute of Tuberculosis.

Implantation of pacemakers for endocardial stimulation (41 cases) was usually performed in two steps (Lagergren et al., 1965). First an electrode was introduced and connected with an external adjustable pacemaker. Fourteen days later a suitable pacemaker was implanted. Out of the total of 65 stimulators, 55 had fixed rate (EM-139, EM-142 Elema, MIP-100 Vitatron), 8 were atrial-triggered (EM-141 Elema), and 2 were ventricular-triggered (EM-143 Elema).

Patients were monitored by radioelectrocardiography when their mobilization was started (1–10 days after

implantation of the endocardial electrode). One-channel radioelectrocardiographic equipment (Officine-Galileo) and sternal M-X leads (manubrium-xyphoid) were employed.

Full mobilization consisted of verticalization, walking in place, walking on horizontal ground, ascending stairs, and in some cases gradually increasing work load on a bicycle ergometer. All the above stages, except for ergometer exercise, were carried out with continuous radioelectrocardiogram monitoring. For the ergometer exercise a standard electrocardiogram was used.

RESULTS

Fixed-rate Pacemakers. In this group of patients premature beats and parasystoles are often encountered. Their frequency is given by different authors as 20 to 50 per cent (Sowton, 1965; Castellanos, Lemberg, and Jude, 1967). We found them in 17 out of 50 patients. They are more frequent in partial or intermittent AV block (13 out of 27) than in complete block (4 out of 23). Since the introduction of demand pacing we have not been using fixed-rate pacemakers in the former group of patients. However, even in fixed third degree AV block atrioventricular conduction can be re-established after the implantation of pacemaker, and thus interference of artificial and natural rhythms can occur. When this happens, the danger of fibrillation arises, as the artificial stimulus may fall in the vulnerable phase of repolarization.

Such parasystoles usually begin during the patient's physical exertion, which speeds up the cardiogenic pacing. In general, we found their frequency to be in direct proportion to the physical effort. More arrhythmias were encountered during ascending stairs than during ergometer exercise, but only
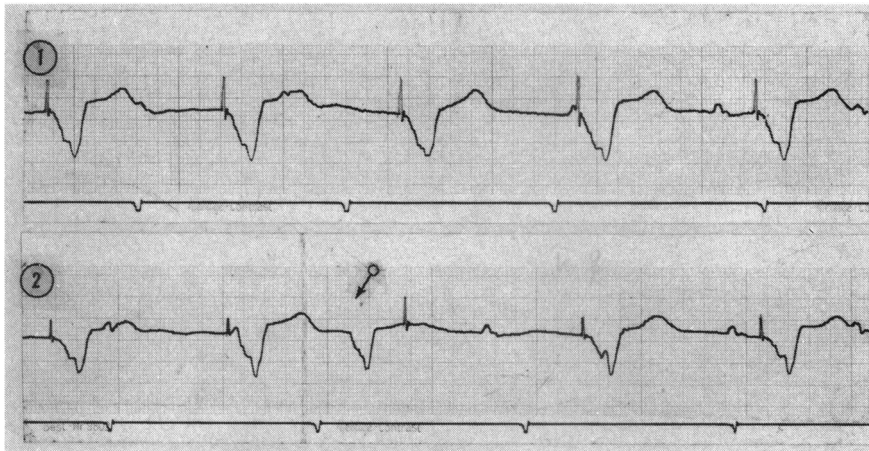
FIG. 1.—Single premature ventricular beats occurring during physical effort (1—at rest, 2—during walking).

a few patients in better condition could be tested with an ergometer.

During physical exertion, when the classical electrocardiogram cannot be used, we have been using radioelectrocardiography with much success in detecting arrhythmias. Examples are given in Fig. 1 and 2.

Patients in whom interference of rhythms has occurred require demand pacing.

Atrial-triggered Pacemakers. These pacemakers mimic all properties of natural impulse formation and conduction. They eliminate the possibility of supraventricular parasystoles, but ventricular parasystoles may still occur. The heart rate cannot exceed a certain value characteristic of the type of pacemaker used (150 a minute for EM-141), otherwise atrial tachycardia may develop. This complication occurred during walking exercise in 2 out of 8 patients with atrio-synchronized pacemakers (Fig. 3b). Fast rates are limited by the "refractory period" of the pacemaker, where the sensing device is blocked for 0·37 sec. after the last impulse has been delivered. Atrial impulses falling in that period do not evoke ventricular response.

Ventricular-triggered Pacemakers. These eliminate any interference of artificial and cardiogenic rhythms (Sowton, 1967). When idioventricular rhythm is faster than 60 a minute, pacemaker impulses are triggered by the potential registered by the endocardial electrode. When the rhythm becomes less than 60 a minute, the pacemaker "waits" for 1 second and then delivers its own impulse. Thus in the absence of idioventricular stimuli, the pacemaker drives the heart at a rate of 60 a minute.

Cardiogenic rhythm can take over as soon as its rate exceeds 60 a minute (Fig. 4).

Displacement of Electrodes. Monitoring by radioelectrocardiography gives important information in cases of rhythm disturbances due to transient displacement of electrodes which have been caused by the patient's movement. Such displacement may impair synchronization as well as stimulation itself. In our experience this kind of disturbance was seen only in patients who were being mobilized in the first 14 days after the introduction of the electrode (Fig. 5).

CONCLUSIONS

On the basis of our experience we suggest that the patients be fully mobilized during the first stage of implantation, i.e. after the endocardial electrode has been introduced and the external pacemaker has been attached in such a way as to permit physical exercise.

Considering the possibility of electrode displacement, patients should not be mobilized earlier than 7–10 days after the introduction of the endocardial electrode or placing an electrode by means of mediastinoscopy.

Monitoring by radioelectrocardiogram during physical activity may detect rhythm disturbances that do not appear at rest.

Radioelectrocardiography can show impairment of artificial stimulation caused by the patient's motion and ensuing transient displacement of the electrode. Such impairment may be very difficult to detect at rest, and even during "stationary" exercise such as on a bicycle ergometer.
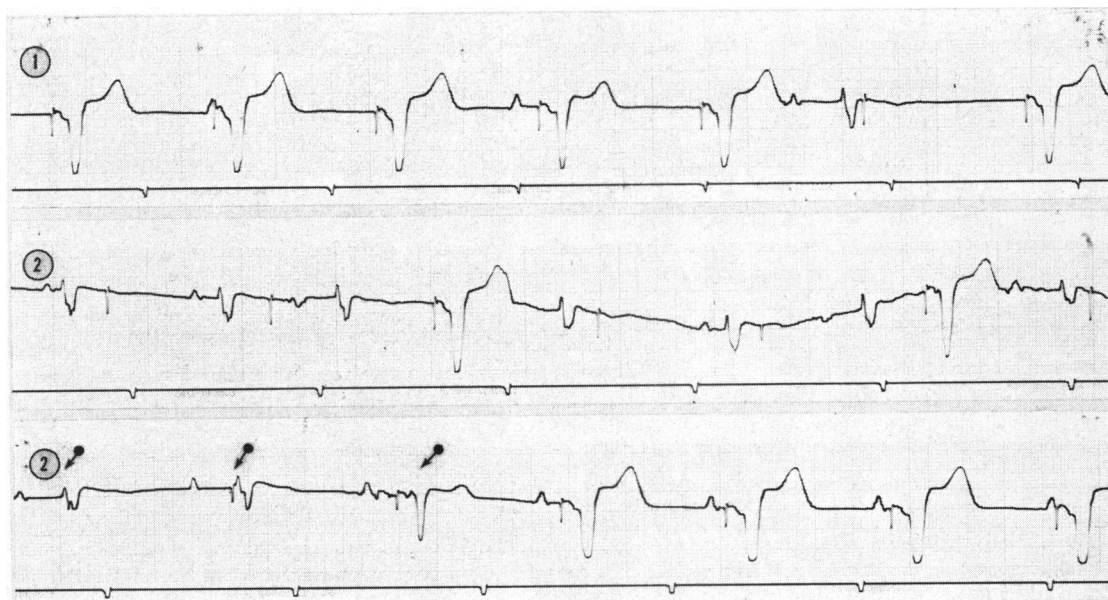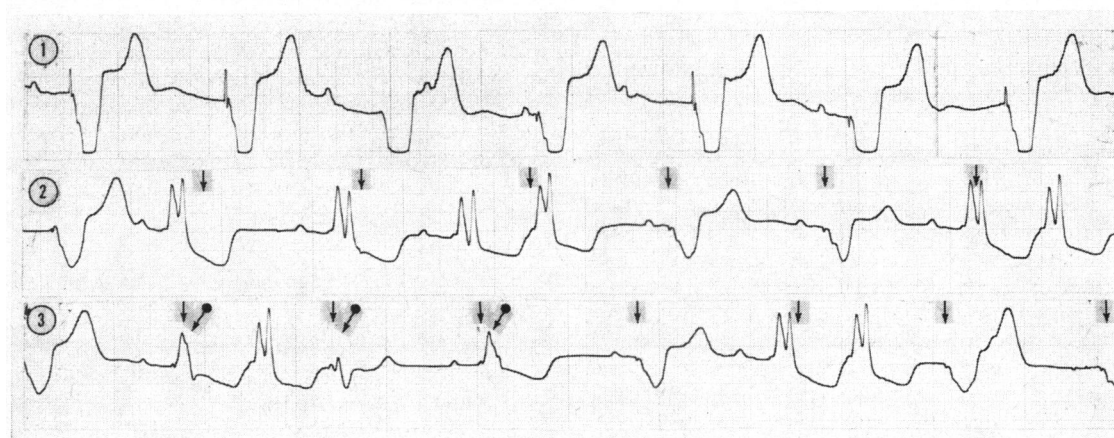
FIG. 2a.

FIG. 2b,

FIG. 2.—Parasystoles appearing: 1—at rest, 2—during walking, 3—during ascending stairs. (a) At rest—the leading rhythm from the pacemaker and periodic competition with sinus rhythm with first and second degree AV block. A faster sinus rhythm appears during walking. The pacemaker impulses evoke ventricular excitation only occasionally, when they fall beyond the ventricular refractory period. When the sinus rhythm slows down, a number of fusion beats appear, with a varying share of each component. (b) At rest—correct pacing at a constant rate of 70 a minute. During walking sinus rhythm with right bundle-branch block can be seen. Bottom trace (continued exertion)—premature beats and fusion beats (♀) as a result of competition. Pacemaker impulses (↓).

A radioelectrocardiogram greatly facilitates the choice of pacemaker to be eventually implanted, since it allows observation of artificial pacing and heart action during physical exertion. This should decrease the number of complications resulting from interference of rhythms.

SUMMARY

The authors introduced radioelectrocardiography as a valuable means of detecting rhythm disturbances during exertion in patients with endocardial electrode and externally attached artificial pace-
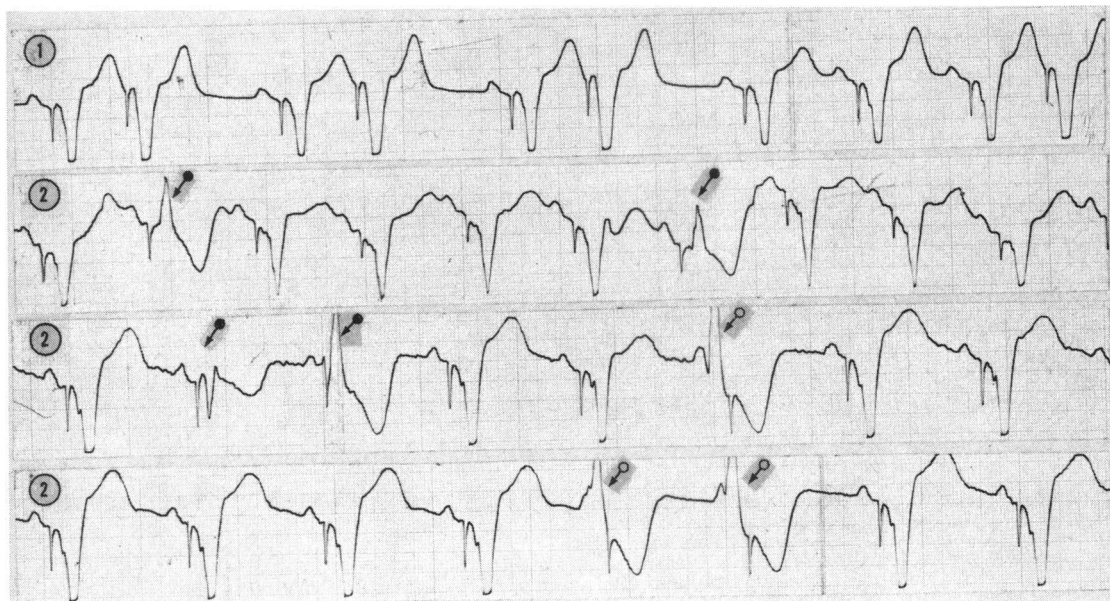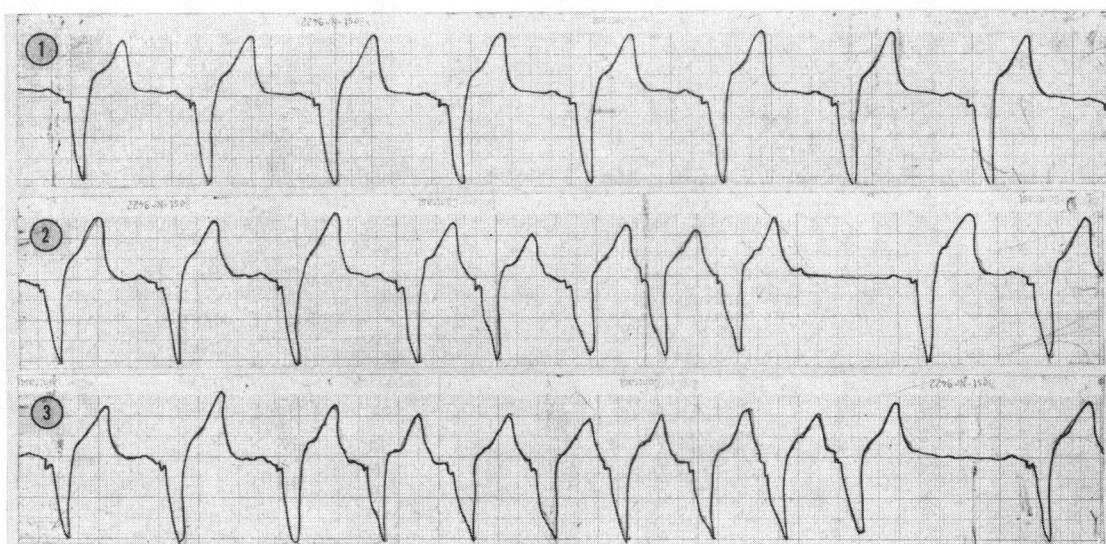
FIG. 3a.

FIG. 3b.

FIG. 3.—(a) Supraventricular premature beats, ventricular pararrhythmia (♀), fusion beats (♀) during walking. (b) Blocking of the excessive rate of cardiogenic rhythm (atrial tachycardia) by the pacemaker refraction system (1—rest, 2—walking, 3—ascending stairs).

maker. This should provide for more precise selection of the type of pacemaker to be implanted.

REFERENCES

Carlens, E., Johansson, L., Karlöf, I., and Lagergren, H. (1965). New method for atrial-triggered pacemaker treatment without thoracotomy. *J. thorac. cardiovasc. Surg.*, **50**, 229.

Castellanos, A., Lemberg, L., and Jude, J. R. (1967). Depression of artificial pacemakers by extraneous impulses. *Amer. Heart J.*, **73**, 24.

Furman, S., Escher, D. J. W., Lister, J., and Schwedel, J. B. (1966). A comprehensive schema for management of pacemaker malfunction. *Ann. Surg.*, **163**, 611.
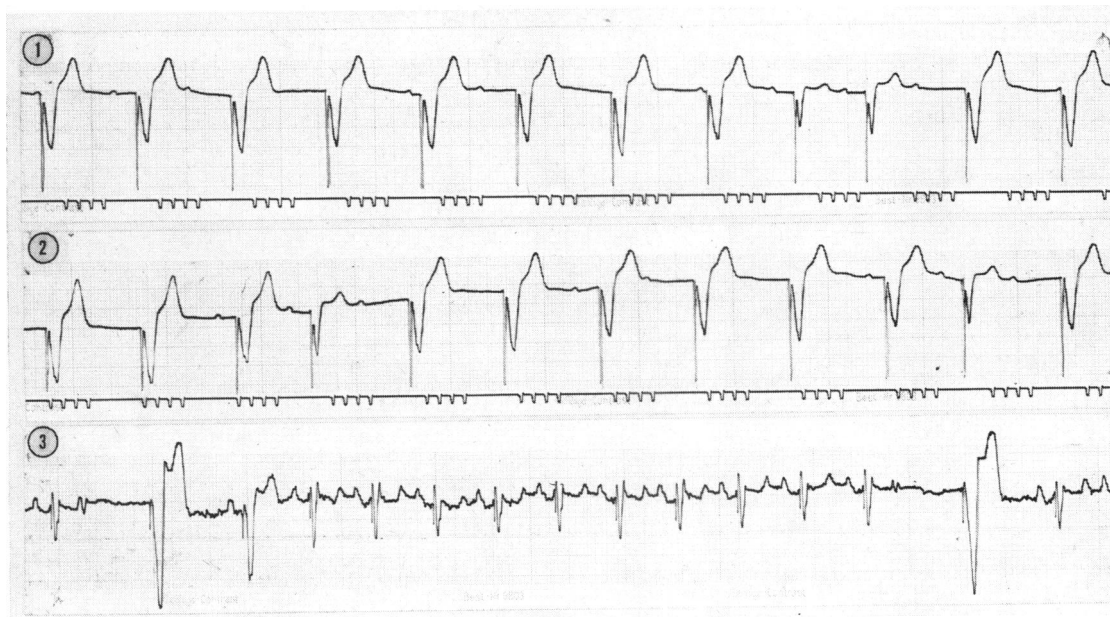
FIG. 4.—Rhythm controlled by ventricular triggered pacemaker. At rest heart is driven by the artificial rhythm of the pacemaker; during exertion synchronized rhythm takes over. (1—rest, 2—walking, 3—ascending stairs).
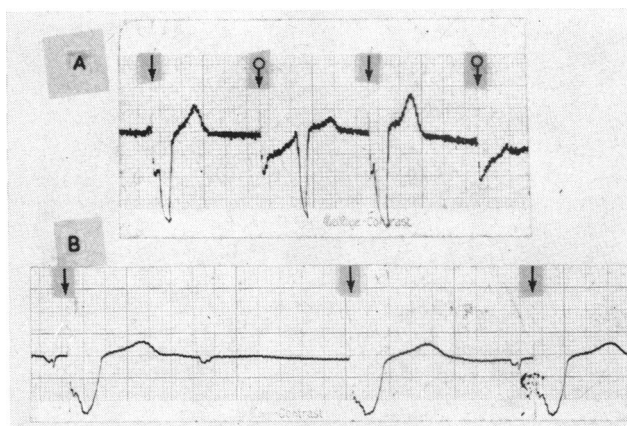

FIG. 5.—A. Some of the stimulating impulses fail to produce ventricular excitation because of displacement of the intracavitary electrode (♀). B. Displacement of the receiving electrode placed by means of mediastinoscopy technique (Carlens et al., 1965), due to the patient's movements. Some of the P waves do not evoke stimulating impulse.

Lagergren, H., Johansson, L., Landegren, J., and Edhag, O. (1965). One hundred cases of treatment for Adams-Stokes syndrome with permanent intravenous pacemaker. *J. thorac. cardiovasc. Surg.*, **50**, 710.

Sowton, E. (1965). Artificial pacemaking and sinus rhythm. *Brit. Heart J.*, **27**, 311.
—— (1967). Current aspects of long term pacing. *Digest of 7th International Conference on Medical and Biological Engineering, Stockholm*, p. 63.